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Why is number word learning hard? Evidence from bilingual learners

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ABSTRACT

Young children typically take between 18 months and 2 years to learn the meanings of number words. In the present study, we investigated this developmental trajectory in bilingual preschoolers to examine the relative contributions of two factors in number word learning: (1) the construction of numerical concepts, and (2) the mapping of language specific words onto these concepts. We found that children learn the meanings of small number words (i.e., *one*, *two*, and *three*) independently in each language, indicating that observed delays in learning these words are attributable to difficulties in mapping words to concepts. In contrast, children generally learned to accurately count larger sets (i.e., *five* or greater) simultaneously in their two languages, suggesting that the difficulty in learning to count is not tied to a specific language. We also replicated previous studies that found that children learn the counting procedure before they learn its logic – i.e., that for any natural number, n, the successor of n in the count list denotes the cardinality $n + 1$. Consistent with past studies, we found that children's knowledge of successors is first acquired incrementally. In bilinguals, we found that this knowledge exhibits item-specific transfer between languages, suggesting that the logic of the positive integers may not be stored in a language-specific format. We conclude that delays in learning the meanings of small number words are mainly due to language-specific processes of mapping

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words to concepts, whereas the logic and procedures of counting appear to be learned in a format that is independent of a particular language and thus transfers rapidly from one language to the other in development.

1. Introduction

Number words like *one*, *two*, and *three*, are learned by young children throughout the world. However, number words are neither universal (Gordon, 2004; Pica, Lemer, Izard, & Dehaene, 2004) nor easy to acquire. Even among highly trained children in countries such as the U.S., Japan, and China, it takes years to acquire the meanings of the first three or four number words, with learning proceeding in distinct and highly protracted stages that are separated by many months (Barner, Libenson, Cheung, & Takasaki, 2009; Le Corre, Van de Walle, Brannon, & Carey, 2006; Li, Le Corre, Shui, Jia, & Carey, 2003; Sarnecka, Kamenskaya, Yamana, Ogura, & Yudovina, 2007; Wynn, 1990, 1992). For example, after English-speaking children in the U.S. learn the meaning of the word *one*, some 6–9 months pass until they acquire a meaning for *two*, and then several more months elapse before they learn the meaning of *three* (Wynn, 1990, 1992). In the present study, we examined two factors – which are not mutually exclusive – that might contribute to these delays between early stages of number word learning: (1) the construction of numerical concepts like "exactly one" and "exactly two", and (2) the language-specific problem of mapping words like *one* and *two* onto these concepts. To examine the contribution of these two factors, we investigated number word learning in bilingual preschoolers, who solve the linguistic mapping problem twice, once for each of their two languages. We reasoned that if the delays between number word stages are primarily due to the problem of constructing new concepts, then once bilinguals acquire number knowledge in one language they should acquire the same knowledge more easily in their second language – i.e., with little additional time required for language-specific mapping of words in their second language. However, if delays between stages are primarily due to the problem of mapping words onto concepts within a particular language, then prior acquisition of number words in a first language should have little effect on children's learning of corresponding words in a second language.

Across a variety of languages and cultural groups, including Canada, the US, Japan, Russia, Bolivia, Slovenia, Taiwan, and Saudi Arabia, children learn number word meanings in distinct, protracted, stages (Almoammer et al., 2013; Barner, Libenson, et al., 2009; Li et al., 2003; Piantadosi, Jara-Ettinger, & Gibson, 2014; Sarnecka et al., 2007; Schaeffer, Eggleston, & Scott, 1974; Wynn, 1990, 1992). In the first stage, which for middle-class American children begins around the age of 2, children learn to recite a partial count list (e.g., *one*, *two*, *three*, *four*, *five*, etc.), often pointing at objects as they count (see Frye, Briasby, Lowe, Maroudas, & Nicholls, 1989; Fuson, 1988; Gelman & Gallistel, 1978). Despite being able to recite the count list, these children actually have little understanding of how number words represent quantity, and as a result are often classified as "non-knowers." Sometime after the age of 2, they advance to a second stage when they acquire an exact meaning for *one*, at which point they are called "1-knowers" (for discussion of what makes this meaning exact, see Barner, 2012; Barner & Bachrach, 2010; Brooks, Audet, & Barner, 2012; Spelke & Tsivkin, 2001a). After a long delay – sometime between 6 and 9 months – children in the US then learn an exact meaning for *two* to become "2-knowers." They then learn *three* ("3-knowers") and sometimes *four* ("4-knowers"). Up until this point, children are generally referred to as "subset-knowers" since they have only acquired the meanings for a subset of their number words. However, at the next stage children appear to recognize that the counting procedure can be used to enumerate sets and, more specifically, that the last word in a count routine labels the cardinality of the entire set (for discussion of knower levels, see Le Corre & Carey, 2007; Le Corre et al., 2006; Lee & Sarnecka, 2011; Piantadosi, Tenenbaum, & Goodman, 2012; Sarnecka & Carey, 2008; Wynn, 1990, 1992; Davidson, Eng, & Barner, 2012). At this stage, children are generally referred to as Cardinal Principle knowers ("CP-knowers").